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## EL NINO DROUGHT HAS SHORT-TERM AFFECT ON RESIDENT DRYLAND FOREST BIRD SPECIES ON MAUNA KEA, HAWAII

El Nino-Southern Oscillation weather events (ENSO) in the Pacific Ocean have caused six major droughts in Hawaii between 1941 and 1983. A 1991-92 ENSO throughout the Hawaiian Islands chain resulted in a 9-month drought from October through June. Total rainfall (<45 mm) was only 18% of the normal rainfall at our study site in the dryland mamane (*Sophora chrysophylla*)-naio (*Myoporum sandwicense*) forest near Puu Laau on southwestern Mauna Kea. The mean monthly number of green seed pods produced in 1992 by mamane, the predominant tree in the study area, was 67% lower than in 1991 and 59% lower than in 1993. Green seed pods from mamane trees are a major food source for the endangered palila (*Loxioides bailleui*); birds also use the nectar and flowers of mamane for food. Despite the regular occurrence of ENSO droughts and the subsequent effects on food resources for birds, little data are available about the effects on Hawaiian bird species. Here we report a short-term effect of the 1991-92 drought on capture rates, fat scores, and active nests of six resident bird species occupying the dryland mamane-naio forest.

### BIRD POPULATIONS WERE SAMPLED

From April through September 1991-93 we operated 10 mist nets at each of four fixed banding stations to capture birds within the study area. Each bird captured was identified to species, banded, and scored for visible fat

within the furcular region before being released. Fat scores ranged from zero for no visible fat to 4 for the interclavicular fossa bulging with fat. We searched for active nests by walking 24 transects (each 40 m × 1 km) at monthly intervals from April through September each year. A nest was considered attended if eggs or nestlings were found, or if the nest was under construction and attended by one or more parents. Data were compared by one-way analysis of variance and Tukey's Studentized Range test.

### CAPTURE RATES DECREASED MORE THAN 50% DURING DROUGHT

The overall capture rate (number of birds per 100 net hours) for all species combined was 49.9 for 1991, 19.2 for 1992, and 47.5 for 1993. During the 1992 ENSO, the overall capture rate was 60% lower than in 1993 and 62% lower than in 1991. As expected, capture rates varied by species (Table 1). Mean monthly capture rates for 1992 were lower ( $P < 0.05$ ) than those for 1991 for common amakihi (*Hemignathus virens*), palila, Japanese white-eye (*Zosterops japonicus*), and house finch (*Carpodacus mexicanus*). Mean monthly capture rates for 1993 increased ( $P < 0.05$ ) compared with 1992 only for common amakihi, and remained lower ( $P < 0.05$ ) compared with 1991 only for the Japanese white-eye.

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## FAT SCORES WERE REDUCED IN TWO SPECIES

Fat scores in 1992 were less ( $P < 0.05$ ) only for common amakihi and Japanese white-eyes when compared with scores from 1991. Two species, common amakihi and palila, had increased fat scores ( $P < 0.05$ ) in 1993 compared with 1992. Fat scores were similar across the 3 years for elepaio (*Chasiempis sandwichensis*), red-billed leiothrix (*Leiothrix lutea*) and house finch.

## ACTIVE NESTS DECREASED MORE THAN 90% FOR TWO SPECIES

During 1992, common amakihi and palila nesting starts decreased 96% and 93%, respectively, compared with 1991 data (Table 1). Our data indicate fewer attended nests for common amakihi in 1993 than in 1991. However, after the drought, common amakihi nesting peaked in winter and spring, as indicated by the large number of juvenile birds captured and vacant nests found in spring and summer 1993. Common amakihi generally nest from November through July on Mauna Kea; breeding usually peaks between March and May. Sample sizes for the remaining four species were low, but data suggest that nesting starts for the red-billed leiothrix and the house finch may also have been reduced (Table 1).

## MANAGEMENT IMPLICATIONS

The 1991-92 ENSO drought reduced capture rates, fat levels, and nesting starts for resident birds, but effects varied by species and seemed short-term. For most species and categories, rates generally increased in 1993 to predrought levels. ENSO droughts that last less than 1 year do not seem to have a significant long-term effect on Hawaiian bird species and, therefore, should not be of major concern to managers. However, endangered birds species with critically low population sizes could be severely effected, especially if ENSO droughts inhibit or prevent their annual breeding cycle. Droughts lasting 1 year or more may effect bird populations for longer durations.

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Table 1. Mean monthly capture rates (number birds per 100 net hours) for six resident bird species on Mauna Kea, Hawaii, April-September 1991-93. Means with the same letter are not significantly different (Tukey's Studentized Range test,  $P < 0.05$ ).

Species	Year			Increased to predrought level?
	1991	1992	1993	
Common amakihi <sup>1</sup>	38.7A	15.5	44.8A	Yes
Palila <sup>1</sup>	2.3A	0.9B	1.9AB	Yes
Elepaio <sup>1</sup>	1.3A	0.4A	0.5A	—
Japanese white-eye <sup>2</sup>	3.4	0.9A	1.0A	No
Red-billed leiothrix <sup>2</sup>	2.4A	1.0A	0.9A	—
House finch <sup>2</sup>	1.2A	0.1B	0.7AB	Yes

<sup>1</sup> Native Hawaiian species.

<sup>2</sup> Alien introduced species.

Table 2. Mean monthly fat scores for six resident bird species on Mauna Kea, Hawaii, April–September 1991–93. Means with the same letter are not significantly different (Tukey's Studentized Range test,  $P < 0.05$ ).

Species	Year						Increased to Predrought level?
	1991		1992		1993		
	n	Mean(SE)	n	Mean(SE)	n	Mean(SE)	
Common amakihi <sup>1</sup>	673	2.25(0.78)A	568	1.93(0.99)	960	2.19(0.96)A	Yes
Palila <sup>1</sup>	64	2.23(0.77)AB	33	1.97(0.88)B	61	2.43(0.83)A	Yes
Elepaio <sup>1</sup>	21	1.62(0.80)A	18	1.00(0.84)A	17	1.65(1.00)A	—
Japanese white-eye <sup>2</sup>	49	2.20(0.73)A	26	1.61(1.13)B	27	2.11(0.80)AB	Yes
Red-billed leiothrix <sup>2</sup>	36	1.58(0.98)A	30	1.60(1.10)A	25	1.12(1.36)A	—
House finch <sup>2</sup>	16	1.81(0.98)A	5	2.40(0.55)A	19	1.58(1.43)A	—

<sup>1</sup> Native Hawaiian species.

<sup>2</sup> Alien introduced species.

Table 3. Number of attended nests for six resident bird species found in 24 transects (each 40 m × 1 km) on Mauna Kea, Hawaii, April–September 1991–93.

Species	Year			Increased to predrought level?
	1991	1992	1993	
Common amakihi <sup>1</sup>	163	6	27	No
Palila <sup>1</sup>	71	5	70	Yes
Elepaio <sup>1</sup>	1	0	0	—
Japanese white-eye <sup>2</sup>	1	1	4	—
Red-billed leiothrix <sup>2</sup>	12	5	4	No
House finch <sup>2</sup>	12	4	8	?

<sup>1</sup> Native Hawaiian species.

<sup>2</sup> Alien introduced species.